Integrated Devices and Photonics

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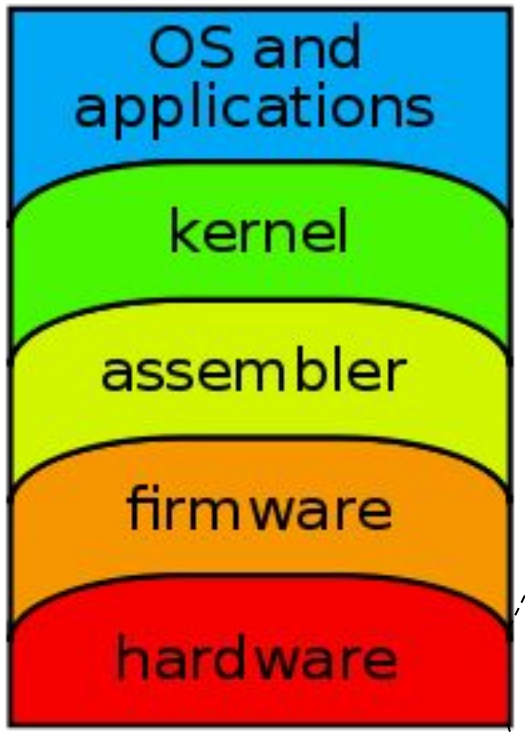
Hierarchy of Technology



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Circuit design

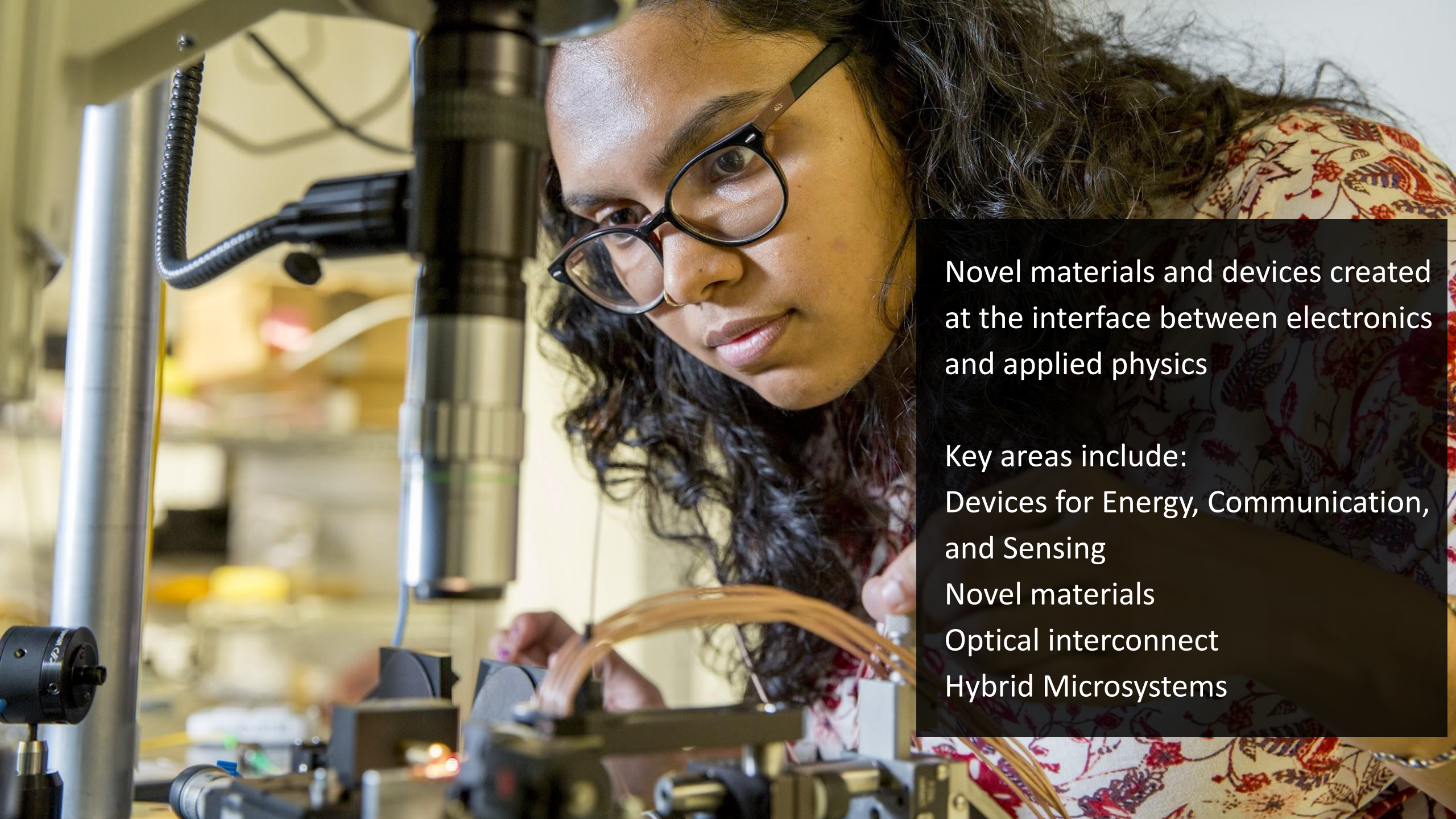
A billion devices

One device

Materials/one atom

Physics + math

Realm of Integrated Devices & Photonics



Novel materials and devices created at the interface between electronics and applied physics

Key areas include:

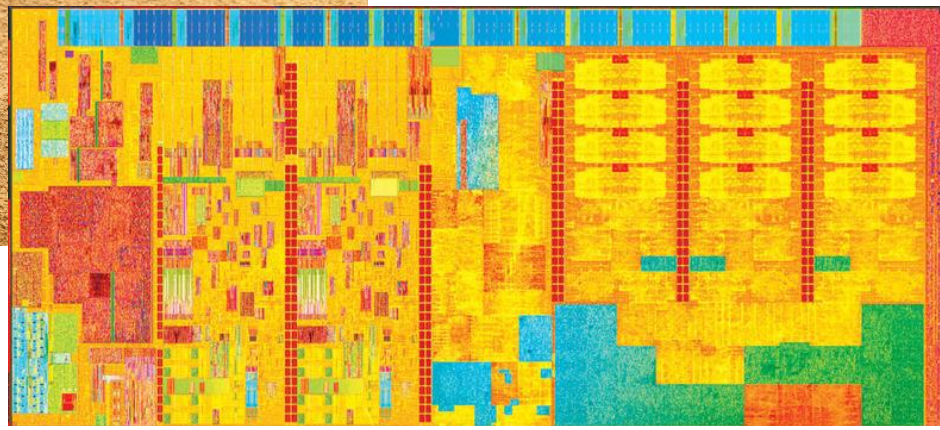
Devices for Energy, Communication, and Sensing

Novel materials

Optical interconnect

Hybrid Microsystems

Microelectronic devices

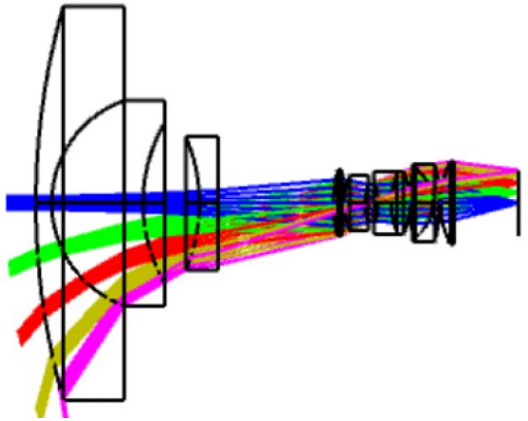


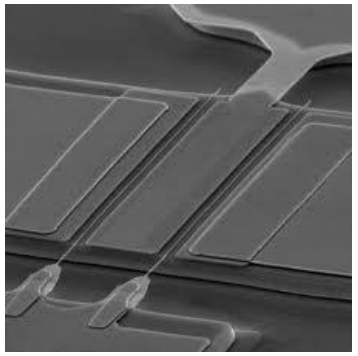
Apple A11 (iPhone 8 + X)
Fabricated by TSMC 10 nm
4,300,000,000 (4.3B) transistors

- Topics:
  - Fabricating devices starting from raw materials
  - Modeling, and understanding their operation (especially the physics of operation)
  - Design of superior devices
  - Operation at the single device level (circuit design is at the multi-device level)
- Useful for careers in silicon microelectronics, MEMS, device modeling, solar energy, and device/material fabrication
- Device physics is foundational for embedded system design

Optics, Photonics and Electromagnetics

- Making devices that generate, measure, or manipulate light and radio waves
- Topics include networking, surface science, optoelectronics device fabrication, displays, data storage, imaging systems and laser technology
- Useful for many careers in science and engineering and for optical and RF circuit design





Integrated Devices & Photonics Senior / Graduate & Advanced Graduate Courses in EE

Directory of Classes
(search for classes by name, time, etc.)

ELEN—Electrical Engineering

APPH, APAM—Applied Physics/Applied Math

BMEN—Biomedical Engineering

COMS—Computer Science

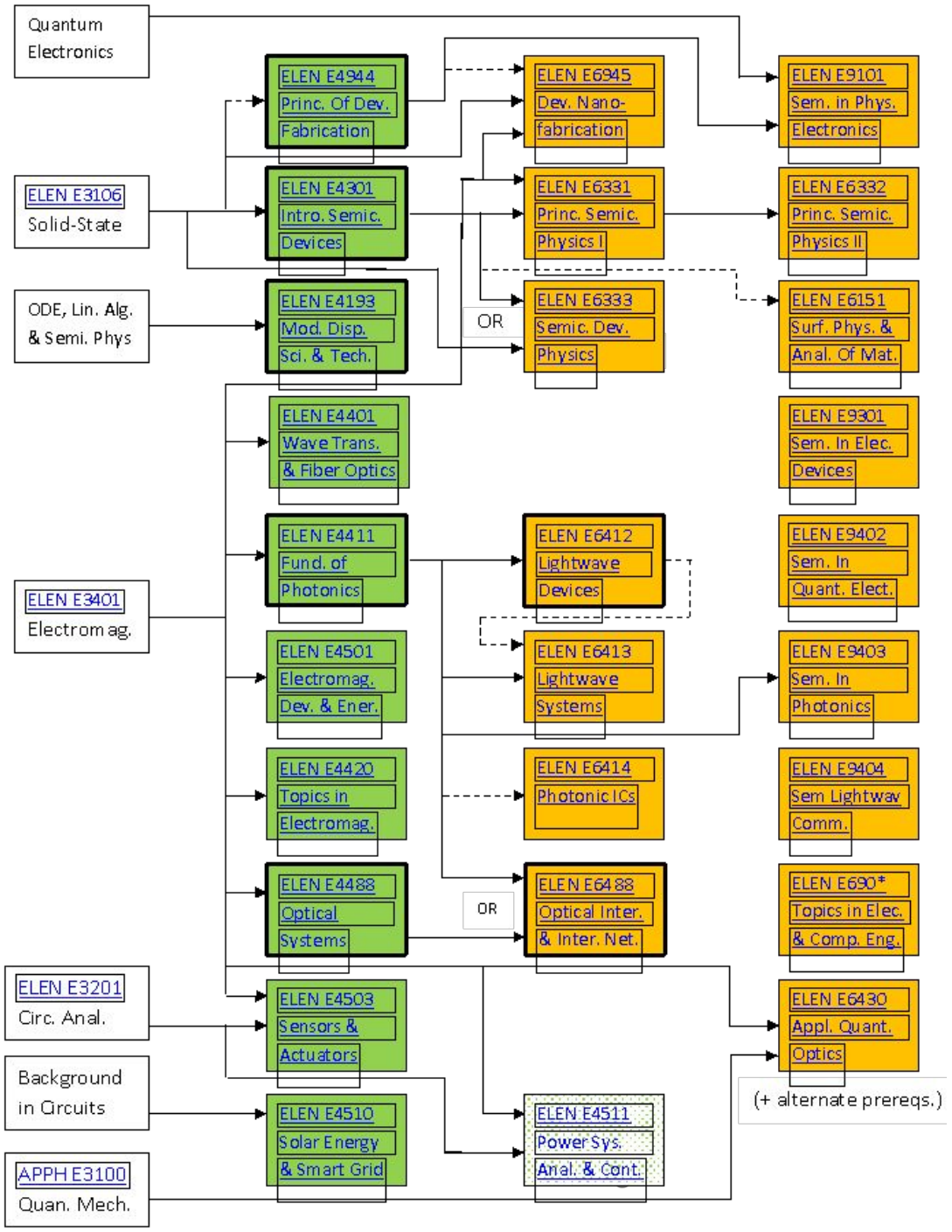
MSAE—Materials Science & Engineering

MECE—Mechanical Engineering

Green - Senior/grad; Orange - Advanced graduate; Bold border - offered regularly; Dotted line - recommended preparation; Updated AUG 2020

Recent related topics courses:

ELEN 88S08 Topic: Nanoelectronic Device Simulations *(Fall '11)*
ELEN 88S03 Topic: Computational Photonics & Quantum Electronics *(Fall '17)*
ELEN 88S06 Topic: Low-Dimensional Nanoelectronics *(Spring '13)*
ELEN 88S07 Topic: Emerging Nanoelectronic Devices *(Fall '18, '16-'17)*
ELEN 88S01 Topic: Theory & Principles of Device Scaling *(Spring '17)*



ELEN E4106 Advanced Solid State Devices and Materials

Fall

Prof Dion Khodagholy Araghy

- Semiconductor devices are the underlying technology in every solid state active electronic circuit. This course will introduce the fundamental concepts of semiconductor physics and statistical mechanics and use them to construct fundamental device models underlying PN diodes, BJTs, and MOSFETs. Along the way, we will see how the same device fundamentals can be used to explain a number of other charge carrier drift/diffusion based devices including photodetectors, biological systems (e.g. nerve conduction and photosynthesis), solar cells, and light emitting devices. This course will build both a student's knowledge of semiconductor fundamentals and basic small and large signal models critical for circuit design

ELEN E441 FUNDAMENTALS OF PHOTONICS
Prof Michal Lipson

Fall

- Planar resonators. Photons and photon streams. Photons and atoms: energy levels and band structure; interactions of photons with matter; absorption, stimulated and spontaneous emission; thermal light, luminescence light. Laser amplifiers: gain, saturation, and phase shift; rate equations; pumping. Lasers: theory of oscillation; laser output characteristics. Photons in semiconductors: generation, recombination, and injection; heterostructures; absorption and gain coefficients. Semiconductor photon sources: LEDs; semiconductor optical amplifiers; homojunction and heterojunction laser diodes. Semiconductor photon detectors: p-n, p-i-n, and heterostructure photo diodes; avalanche photodiodes.
- Prerequisites: ELEN E3401 - Electromagnetics or equivalent.

Fall

ELEN 4488 OPTICAL SYSTEMS
Prof Christine Hendon

- Introduction to optical systems based on physical design and engineering principles. Fundamental geometrical and wave optics with specific emphasis on developing analytical and numerical tools used in optical engineering design. Focus on applications that employ optical systems and networks, including examples in holographic imaging, tomography, Fourier imaging, confocal microscopy, optical signal processing, fiber optic communication systems, optical interconnects and networks.
- Prerequisites: ELEN E3401 - Electromagnetics equivalent.

ELEN 6091 Topics in Computational Neuroscience and Neuroengineering Prof Dion Khodagholy

Fall

- *TPC: Devices and Analysis for Neural Circuits*
- A comprehensive overview of devices and analytical techniques that enable investigation and decoding of neural circuits. Introduction to brain, brain states and neural networks. Neural devices and their spatiotemporal resolution. Time domain neural analysis. Frequency domain neural representation. Phase, traveling waves and wave propagation. Closed-loop real time processing. Template matching for event detection. Clustering and sorting

Fall

ELEN E6333 – Semiconductor Device Physics
Prof Alex Meng

- This course covers the physics of semiconductor devices for silicon integrated circuit applications - with an emphasis on the basic concepts of quantum theory of solids, to describe the carrier behaviors in semiconductors, and its application to semiconductor electronic devices. Issues in modern device scaling will be outlined. Topics: semiconductor fundamentals (including carrier statistics, generation & recombination, drift & diffusion, and carrier flow), pn junctions, metal-oxide-semiconductor (MOS) structures, metal-semiconductor junctions, and long- and short-channel metal-oxide-semiconductor field-effect transistors (MOSFETs)

- Prerequisites: ELEN3106 or equivalent is recommended, but not required.

Courses in Microelectronics

Fall

- E4106 Advanced Solid State Devices and Materials
- EEBM 6901 Devices and Analysis for Neural Circuits
- ELEN 6333 Semiconductor Device Physics

Spring

- ELEN 4944 Principles of Microfabrication
- ELEN 6903 Nanoelectronic Device Simulations
- ELEN 6331 Principles of Semiconductor Physics

Courses in Optics, Photonics and Electromagnetics

Fall

- ELEN 4193 Modern Display Science and Technology
- ELEN 4411 Fundamentals of Photonics
- ELEN 4488 Optical Systems
- ELEN E6488 – Optical Interconnects and Interconnection Networks

Spring

- ELEN 6412 Lightwave Devices
- ELEN 6413 Lightwave Systems
- ELEN 6414 Photonic Integrated Circuits

Other Relevant and Complementary Classes

ELEN 4703 Wireless Communications

APPH 4300 Applied Electrodynamics

APPH 6101 Plasma Physics I

APPH 4110 Modern Optics

APPH 4130 Physics of Solar Energy

APPH 4100 Quantum Physics of Matter

APPH 6081 Solid State Physics I

APPH 4301 Introduction To Plasma Physics

APPH 6102 Plasma Physics II

APPH 6082 Solid State Physics II

BMEN 4430 Principles of Magnetic Resonance imaging

BMEN 4894 Biomedical Imaging

BMEN 4898 Biophotonics

CHAP 4120 Statistical Mechanics

MSAE 4206 Electronic and Magnetic Properties of Solids

MECE 4210 Energy Infrastructure Planning

MECE 4212 Microelectromechanical Systems

MECE 4213 Bio-microelectromechanical Systems (BioMEMS): Design, Fabrication and Analysis

ELEN—Electrical Engineering

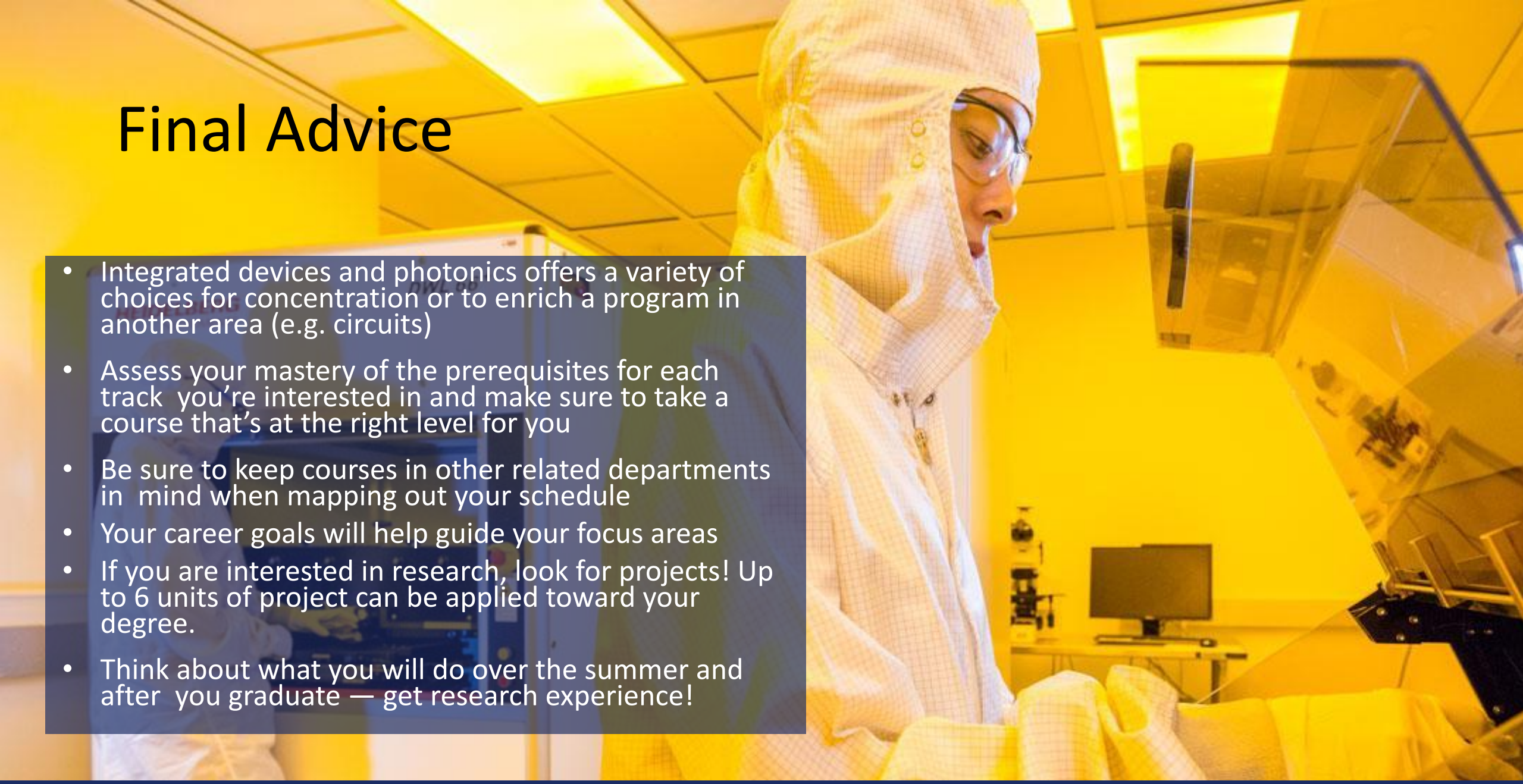
APPH—Applied Physics

BMEN—Biomedical Engineering

MSAE—Materials Science & Engineering

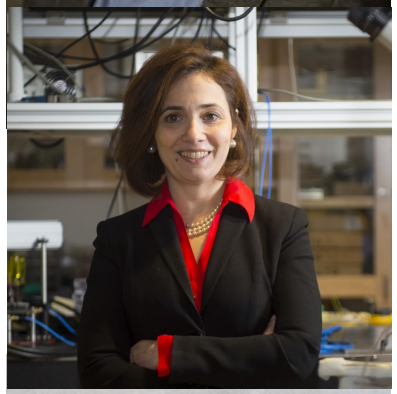
MECE—Mechanical Engineering

Final Advice



- Integrated devices and photonics offers a variety of choices for concentration or to enrich a program in another area (e.g. circuits)
- Assess your mastery of the prerequisites for each track you're interested in and make sure to take a course that's at the right level for you
- Be sure to keep courses in other related departments in mind when mapping out your schedule
- Your career goals will help guide your focus areas
- If you are interested in research, look for projects! Up to 6 units of project can be applied toward your degree.
- Think about what you will do over the summer and after you graduate — get research experience!

- **Keren Bergman.** Large-Scale Optical Switching Fabrics, Optical Interconnection Networks for High-Performance Computing, Optical Interconnection Networks for Data Center Computing Systems, Integrable Interconnection Network Systems and Subsystems, Inter-Chip Multi-Processor Interconnection Networks.
- **Christine Hendon.** Biomedical optics, near infrared spectroscopy, optical system design.
- **Ioannis (John) Kymissis.** Solid state devices, organic electronics, thin film systems.



- **Dion Khodagholy.** Bioelectronics, Conformable Electronics, Mixed Conducting (ionic and electronic) polymer devices, Biosensors, Neural Interface Devices, Translational Devices, Systems Neuroscience, Computational Neuroscience.
- **Michal Lipson.** Novel Photonic Materials and Fabrication, Silicon Photonics and Non-Reciprocity, Nano-Magnetism and Thermal Control, Nanophotonics for Neuroscience, Optomechanics, Nonlinear and Quantum Optics, and Sensing and Optofluidics.
- **Wen Wang.** optoelectronic materials, devices, and molecular beam epitaxy. nano and heterostructure material properties, optoelectronic devices, infrared lasers, detectors, and photovoltaics